(Lord Kelvin) and his successors. Motion on a rotating globe; Ferrel's and other simple approximate relations between baric gradients and the wind and temperature; Ferrel's general circulation of the atmosphere and his cyclones and pericyclones and tornados. Galton's cyclone and anticyclone. Fourier's most general equations of gaseous motions. Oberbeck's general circulation. Helmholtz's horizontal rolls. The investigations of Diro Kitao, Guldberg and Mohn, Marchi, Boussinesq, A. Poincaré, Sprung, Siemens, Moeller, Ritter, and others into the motions of the atmosphere. Viscosity and discontinuous movements. The possible special solutions of the general equations of fluid motions that apply to the true atmospheric circulation, both on the earth and on the other planets. Atmospheric tides; theories of Laplace, Ferrel, Rayleigh, Margules, A. Poincaré. Theories of atmospheric electricity.

Time.—Eighty lectures and an additional four hours a week given to special reading and investigation, and to the preparation of the final thesis, as closing the four years' course.

Concomitant Studies. — Riemann's "Differential Gleichungen"; Auerbach's "Hydrodynamics"; Lamb's "Fluid Motions" (new edition); physical laboratory work in gaseous motions, optical and electrical phenomena.

THE ROYAL PHOTOGRAPHIC SOCIETY.

SIR H. TRUEMAN WOOD, the new President of the Royal Photographic Society, delivered an address at the opening meeting of the present session on Tuesday. After briefly tracing the development of the Society, he said:

"Turning aside from the consideration of the affairs of our own Society, to the general condition of photography, we find cause for nothing but congratulation. It is not so very long since photography occupied a very subordinate position in the world alike of science and of art. Scientific men looked on photography as a mere art, artists regarded it as a mere science. About twenty years ago, when I suggested that some improvement in a photographic process—I forget now which—ought to be brought before the Physical Section of the British Association, I was told that there was nothing scientific about photography, that it was a mere empirical pursuit, unworthy the attention of serious students of science.

"And to a large extent the reproach was well deserved. Though the list of the earliest workers in photography contains many illustrious names, yet it is true that a large proportion of the most important contributions to photographic knowledge were not made by scientific workers, or by men who worked in scientific methods. They were obtained by practical men, seeking for results; often, indeed, seeking for them successfully by methods which would not have commended themselves to men better equipped with scientific knowledge. Of course this was the consequence of the fact that photographic science was early associated with photographic practice; and the same remark holds good of other sciences, electricity for instance, in which theory and application to practical use advance with equal steps; but I think it applies more to photography than to any other.

"At the present time we have indeed reached a very different condition of things. All the most striking of the recent advances in the science are the result of elaborate scientific research. The most recent improvements in lenses were the fruit of long and laborious investigation into the optical properties and the chemical nature of certain sorts of glass. The increased speed of modern plates, and their improved power of rendering colour values more truly, have only been obtained by minute knowledge of the condition of the problem to be solved, and by careful application of the most recent results of chemical and physical research. If the old photographic crux, the reproduction of colour, has been solved, or, at all events, if a possible method has been indicated for its solution, it was not by haphazard experiment, but by careful adjustment of means to secure an anticipated result. Nowadays, we can only hope for improvement by utilising the advance of scientific knowledge.

"But if the present position of photography is due to progress in the kindred sciences, how amply has she repaid the debt! There is not a single branch of science in which photography is not largely used. There are many whose progress is now absolutely dependent on the power of the camera to observe more accurately, more independently, more minutely, more rapidly, more permanently, than the human eye. If, as appears to be the case, we have reached the limits of human vision, aided by the most delicate instruments that can be constructed, it is difficult to imagine what limits need be set to photographic vision, can we but construct instruments of accuracy sufficient to allow its full powers to be utilised.

"I imagine that the first application of photography to a scientific purpose must have been when Dr. Draper in New York photographed the moon. Whether the pictures he obtained were of any astronomical value, I do not know; certainly those taken a little later, in 1852, by Dr. Warren De la Rue, were, and they were the precursors of the long series of astronomical photographs culminating in Dr. Common's nebula of Orion, and in the great work of charting the heavens by photography which is now in progress.

"The advantages of the 'retina which never forgets,' and it might be added which never tires, which accumulates weak impressions and stores them up till they become one strong one, were long since recognised by De la Rue, and I suppose it will not be very long before, for astronomical purposes, eye observations are entirely superseded by photographic. The photographic camera is now an indispensable adjunct to every large telescope, if indeed it would not be equally correct to say that the telescope is an adjunct to the camera, since the astronomical telescope tends more and more to assimilate to the form adopted long since by Mr. Rutherford, in which the visual rays are treated of but slight importance, and the chief attention is given to the accurate utilisation of the more chemically active rays at the violet end of the spectrum.[1]

"In his recent address to the Photographic Convention at Dublin, Sir Howard Grubb, than whom nobody is better qualified to speak on the subject, dwelt on the services which photography has rendered to astronomy, and gave several striking illustrations of those services. Indeed, if one not qualified to speak on such matters with any authority might hazard an opinion, it would almost seem as if the power of recording observations had already outstripped the capacity for examining the observations, and drawing conclusions from them. When we are told that a photographic plate has recorded 10,000 stars in an area not containing a single visible star, one may be excused an expression of wonder as to how the human mind is ever to grapple with problems of such infinite complexity, to turn to useful account observations dealing with such enormous multitudes.

"But if the telescope has lately become one of the most important of photographic appliances, the spectroscope may be said to have held that position almost since its introduction. Mr. Norman Lockyer, in his well-known text-book, "Studies in Spectrum Analysis," attributes to

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[1] A good illustration of the telescope of the future would appear to be the 24-inch photographic refractor with an 18-inch visual telescope, now being constructed at the expense of Mr. McLean for the Cape Observatory.

Sir John Herschel the first suggestion of spectrum photography, and we find that in 1839 the latter pointed out that the way to investigate sensitiveness was to photograph the spectrum. In the following year he read a paper describing his results of spectrum photography. A little later, in 1842, Becquerel and Draper were both at work photographing the solar spectrum. Twenty years later (in 1864) Miller was turning to practical account the power of photography to record the parts of the spectrum beyond the limits of human vision, and from that date nearly all spectroscopic work has been photographic work. Whether applied to astronomical observation or chemical research, the spectroscope has always been combined with the camera, and it is by the combination of the two instruments that such wonderful results have been attained. And as photographic methods have improved, so have fresh facilities been afforded to the spectroscopic worker. Mr. Lockyer's earlier work was of necessity done with wet plates, but with the plates now available he is producing star spectra on a scale comparable with the solar spectra of twenty-five years ago.[1] Rutherford's recent maps of the solar spectrum could not have been produced without the use of colour-sensitive plates, while in one of the most recent attempts to employ spectroscopic analysis for purposes of practical metallurgy[2] Prof. Hartley tells us that he also used orthochromatic plates, specially prepared, and that after trying various developers he found hydroquinone the best.

"As an automatic recorder of scientific observations, photography seems to have been utilised in the Royal Observatory about 1847, under the superintendence of the venerable ex-president of this Society, Mr. Glaisher, who has been kind enough to furnish me with particulars of the methods originally devised by Mr. Charles Brooke, and successfully worked for many years by Mr. Glaisher and his staff.

"The method was first applied to record magnetic variations and the movements of the barometer and thermometer. In the case of the former, a ray of light reflected from a mirror carried by the magnet was focussed on the surface of a cylinder covered with sensitised paper.[3] The cylinder was rotated by clockwork, the result being, of course—in the way now commonly employed for such automatic records—to give, when the image was developed, a record of the movements of the magnet. A base line was given by an invariable spot of light, and by intermissions of this light a time record was provided. Similar results were obtained in the case of the barometer by using a float with a small perforation through which the light passed, and with the thermometer by simply allowing the mercury itself to screen the light from the sensitive surface.[4]

"Later on, in 1865, similar means were used by Mr. Glaisher for the automatic record of earth-currents, and they have consequently been continuously observed since that date at Greenwich.

"To the best of my knowledge but little alteration has been made in the original system, the only improvement being in the sensitive surface employed. When gelatino-bromide paper was introduced, it was tried and adopted at Greenwich, and by its means superior results were obtained.

"I have ventured to dwell at some little length on this part of the subject, not because what I have said can be novel to any of you, but because I think this first application of photography to automatic observation has considerable historical interest, and also because this application was carried out by one so long and so honourably connected with this Society.

"The principle thus first applied at Greenwich has received numerous other applications, and indeed it is now a matter of course that photographic methods should be used to register the movements of any instrument of whose indications it is desired to preserve a record. Instances are of course numerous in which no other method is possible. Hardly any but a photographic method could register the movements of the light spot of a reflecting galvanometer, and thus enable the physicist who, like Langley, is measuring the heat radiated from celestial bodies, to record the minutest differences of temperature; the chemist, like Dewar, who is producing hardly imaginable cold, to record temperatures approaching absolute zero; the metallurgist, like Roberts-Austen, who is dealing with the melting points of metals, to register by a photographically traced curve variations in high temperatures which but a short time ago could not be accurately measured at all. It is interesting to read the testimony of the last named, given at the recent conference of the Camera Club, to the effect that he could not conceive of any method which would give such results in the same space and time. Equally interesting is it to note the Professor's suggestion for a practical method of recording continuously the temperature of the air-supply of a blast furnace, a matter of great importance to the iron manufacturer, of which he says:—'If we had no photography it would be impossible to get a record which would be anything like so true.'

"Numerous other instances will occur to many of you in which photography has been or might be—indeed I may say will be—applied to similar purposes. I will only refer to one, because it appears to me so excellent an instance of the delicacy of the method. At the last (the Oxford) meeting of the British Association, Mr. Burch showed to the newly-formed Physiological Section photographic records taken with the aid of the capillary electrometer of electrical currents produced by speaking into the telephone. The letter *z* produced a complicated curve in which oscillations of current lasting only 1/3000 sec. were visible with a lens.

"It seems hardly worth while to trouble you with the details of many of the other services which photography has rendered to science, and if I were to attempt to produce an exhaustive list, there are many present to-night who could supplement it out of their own knowledge. The meteorologist has been enabled by its aid to study the form and nature of clouds, the shape and character of the lightning flash. The zoologist has been taught much about animal motion. The microscopist has long learnt to rely on the camera as the only accurate means of reproducing the objects of his studies. The physicist has by photographic methods investigated many phenomena in which the changes are too rapid for the human eye to follow them. By such means Lord Rayleigh and Prof. Boys have obtained long series of pictures of occurrences which all took place within a fraction of a second, thus almost analysing time as the chemist analyses matter.

"The uses of photography in ethnology, geology, geography, natural history, archæology, are too obvious to need mention. They and many other applications may be summed up in the remark that whenever the observer of natural phenomena requires to make an accurate record of his observations, photography supplies the means. It also supplies the means of showing to a room full of spectators what could otherwise be seen by but a single observer at one time, and has thus rendered to the popularisation of science no less a service than it has lent to its advancement. This universal use of photography for purposes of demonstration must certainly not be forgotten in however brief a summary of its applications."

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[1] "Photographic Spectra of some of the Brighter Stars." *Phil. Trans.*, vol. 184 (1893), A., p. 675 *et seq.*

[2] "Flame Spectra at High Temperatures." *Phil. Trans.*, vol. 185, A., p. 161 *et seq.*

[3] The method employed was a form of the old calotype process. Paper treated with potassium bromide and iodide was afterwards sensitised with silver nitrate. The development was by gallic acid.

[4] For a full account of the apparatus reference may be made to an addendum to the introduction to the Greenwich magnetical and meteorological observations for 1847.

The services of photography to art were next touched upon by Sir H. T. Wood, who afterwards went on to say:

"The interesting investigations of Buchner and Marshall Ward into the action of light on bacteria can hardly with justice be admitted as adding to the list of photographic materials, though we must certainly claim the photobacteriograph ' as an advance in our science and as suggesting new directions for photographic work.

"The question of sensitometry has exercised the minds of many of our most active workers for some time, but I think I may say without as yet any positive result. I believe I may put it as the opinion of those best qualified to express an impartial judgment on the subject, that while we have certainly obtained a means of roughly gauging the comparative sensitiveness of plates, and have got a guide of great practical use to the makers and users of plates, we are as far as ever from an absolute standard, and that the attainment of such a standard must await the attainment of a standard of light, a problem the solution of which is of importance not to photographers alone.

"It would obviously be unreasonable to expect that the increase of photographic knowledge should grow *pari passu* with the number of those who practise the art, but I think it is certainly a matter for regret that of the many thousands who have taken up photography as a pastime, so very few pursue it in a serious way, or in a scientific spirit. The popularisation of photography has indeed to my mind been a drawback to real progress. The process of picture-making has been rendered so easy that it has been deprived of much of its interest, even to the merest amateur in science, and the attention of those who might have pursued photography seriously has been diverted to other branches of science. Still we are fortunate in having, even among the younger workers, a considerable band of capable and active students who are adding slowly but surely to our knowledge of the scientific principles of the art.

"In photographic optics there is, I think I may say, a very distinct advance now going on. The expectations of opticians have long been fixed on the productions of the Jena manufactory, and those expectations are, according to the best information at my disposal, now in a fair way of being realised. The qualities of glass that are to be obtained commercially from Jena have provided the opticians with new possibilities for the improvement of photographic lenses. Both in this country and in Germany opticians are availing themselves of these possibilities. Great credit is certainly due to Messrs. Ross, who have carried out the work of Dr. Schroeder, and have produced from his calculations the lens which they have termed the 'concentric' lens. The double anastigmat of Goerz, described last year to the Society by that gentleman, is another new lens, the outcome of the Jena improvements in glass, which ought at least to receive mention.

"Mr. Dallmeyer has also made considerable advances, both theoretical and practical, in his 'telephotographic' lens, an instrument which produces results appealing at once to all who take any interest in photographic matters, and one which, in the opinion of competent authorities, is likely to have important practical applications for astronomical and other branches of scientific photography."

WILLIAM TOPLEY, F.R.S.

A GREAT gap has been made in the ranks of active geologists by the death of William Topley, which took place on the night of Sunday, September 30, at his house at Croydon. He was taken ill, with gastritis, probably from the use of contaminated water, in Algiers, during a short visit, made in reference to its geology; and he fell, therefore, in the fighting line of those who apply their scientific knowledge for the good of mankind.

He was ill whilst travelling home, and though after a time he began a slow recovery, a relapse came on Saturday, September 29, which soon proved fatal.

Born at Greenwich in 1841, he had reached an age when, though the physical powers may have begun to wane, yet the mental powers are reinforced by stores of knowledge and of experience, and the value of a scientific life is high.

His scientific education was at the Royal School of Mines, Jermyn Street. Soon after his student-life was ended, he joined the Geological Survey (early in 1862), and his future career was identified with that Survey, of which he was one of the oldest and best-known officers at the date of his untimely death.

For many years his work lay in the counties of Kent, Surrey, and Sussex, in the investigation of the great district of the Weald and its surroundings, with which his name will ever be linked.

He made his mark as a good observer of facts and an able reasoner from them in 1865, by the paper, read to the Geological Society, "On the Superficial Deposits of the Valley of the Medway, with Remarks on the Denudation of the Weald," which was written jointly with his then colleague, Dr. C. LeNeve Foster. This is a most important essay, in which the general question of inland erosion is discussed, and the special question of the processes of denudation that had acted over a definite tract, on which much had been written, may be said to have been practically settled, an achievement of no small merit.

In 1866 Mr. Topley supplemented his knowledge of our Wealden deposits by a visit to the Boulonnais, a tract that really contains the severed eastern end of the Weald, a visit in which the writer had the pleasure of accompanying him, and the results of which were given to the Geological Society in 1868.

He soon turned his attention to the bearings of geology on other branches of knowledge, and in 1871 the Royal Agricultural Society published a paper by him, "On the Comparative Agriculture of England and Wales," followed, in the next year, by another, "On the Agricultural Geology of the Weald."

In 1873 a paper was printed by the Anthropological Institute, in which he treated of the relation of parish boundaries to great physical features. This was illustrated chiefly from parts of the Weald and its borders; but references were made to other parts, and amongst them to Northumberland, to which county he had been transferred from the south.

In 1874 he gave the Geological Society a very suggestive paper "On the Correspondence between some Areas of Apparent Upheaval and the Thickening of Subjacent Beds," in which he pointed out that an apparent dip (over a large tract) may be partly owing to the thinning of beds underground.

In 1875 appeared the work by which he will probably be best known, and in the writing and compiling of which he may be said to have raised his own monument. The Geological Survey Memoir on the Weald is noted, not so much for local details (of which, however, there are many) as for the thorough way in which the literature of the subject is treated, for the full discussion of the subjects of physical geology, scenery, and denudation, and for the attention given to many branches of applied geology. The parts mentioned indeed take up more than half of the text, adding greatly to the interest of the book.

Naturally the important work of the Sub-wealden Boring was not done without Mr. Topley's help.

In 1876, he used his northern experience in the field in joining his friend Prof. Lebour in a paper to the Geological Society, on the intrusive nature of the Whin Sill, published the following year.